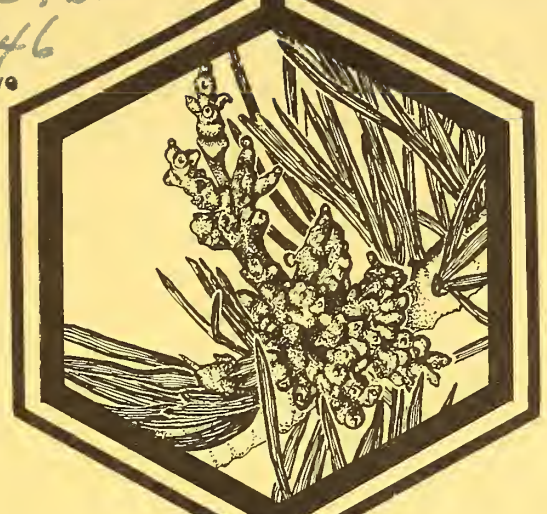
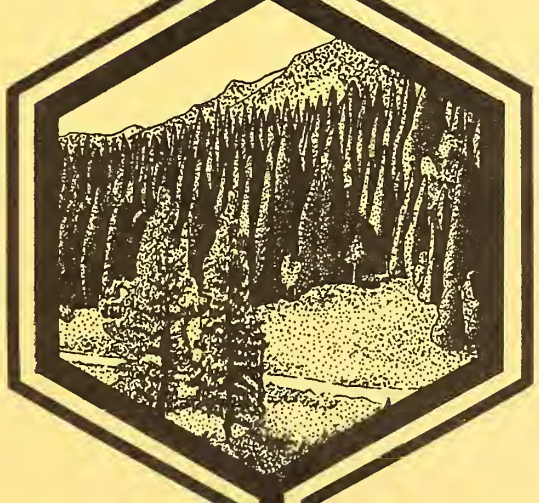
REPORT NO. 80 - 10





PREDICTION OF WESTERN SPRUCE BUDWORM DEFOLIATION ON DOUGLAS-FIR

Methods Application Group
Forest Insect and Disease Management
Forest Service, USDA
2810 Chiles Road
Davis, California 95616

TABLE OF CONTENTS

Report 80-10

3400
August 1980

PREDICTION OF WESTERN SPRUCE BUDWORM DEFOLIATION ON DOUGLAS-FIR

Allan T. Bullard and Robert W. Young[1]

ABSTRACT

A series of equations have been developed to predict defoliation on Douglas-fir caused by the western spruce budworm. These are based on egg mass density and result from data collected westwide from 1976 to 1979. Analyses presented are based on year of data collection, the combination of all data to produce a single equation, and the grouping of data by age of infestation. Use of the appropriate model will allow prediction into the correct defoliation category 8 out of 10 times.

INTRODUCTION

Western spruce budworm, Choristoneura occidentalis Freeman is a defoliator of Douglas-fir and true firs in western North America. Egg mass density has been used to monitor population trends, evaluate long-term efforts of control projects and forecast defoliation by this insect.

Egg mass survey methods were developed by Carolin and Coulter (1972) for Oregon and by McKnight, et al. (1970) for Colorado. These were reasonably successful when used in the areas for which they were developed but westwide application has been unreliable.

The need for consistent prediction methods westwide, led to the formation of a Western Spruce Budworm Egg Mass-Defoliation Working Group in 1976 (Grimble and Young 1977). This Group consisted of forest entomologists from USDA-Forest Service Regions 1, 2, 3, 4, 6, the Intermountain Forest and Range Experiment Station, and the FIDM Methods Application Group. The Group's objective was to coordinate collection of egg mass data and conduct analysis to:

1. Develop reliable defoliation prediction models for Douglas-fir based on western spruce budworm egg mass densities

2. Make procedures comparable westwide for egg mass sampling, descriptions of defoliation, and reporting of results of egg mass surveys

---

1 Authors are, respectively, Survey Entomologist and Biometrician, USDA Forest Service, Forest Insect and Disease Management, Methods Application Group, Davis, CA.

METHODS

Data collection was based on repeated sampling from the same trees and sampling units for a three-year period. Standardized methods for egg mass collection, defoliation estimation, and reporting were developed and used beginning with the 1976 field season and continued through the 1979 field season. This has resulted in the largest known data base of this kind ever compiled.

Field Procedures

Entomological Unit. The Entomological Unit was the smallest area for which a defoliation prediction was made. These had the following attributes:

1. A distinct geographical area
2. A distinct management unit
3. An area of contiguous susceptible host type
4. Contained an active western spruce budworm infestation

Entomological units varied from 1000 to 100,000 acres in size. Each Region determined unit boundaries and the number of units to be sampled.

Clusters. Estimates of egg mass density and defoliation prediction were made from clusters of 3 sample trees each. Easily accessible clusters were randomly located throughout each entomological unit in areas of visible defoliation. A minimum of 20 clusters was recommended for each unit.

Sampling. In each cluster, three Douglas-fir 30-60 feet in height, open grown, with light to moderate defoliation were selected as sample trees. Heavily defoliated trees were not sampled because they did not contain sufficient foliage for oviposition. Field sampling was conducted during late July or August after most adult activity had ceased.

One 70 cm branch was removed from each quadrant of the mid-crown of each sample tree with a pole pruner. These were used to classify defoliation intensity. Two branches were returned to the laboratory for egg mass counts.

Description of defoliation - Defoliation was estimated from the first 25 current shoots on each branch, starting from the tip. Shoots were taken from alternate sides of branches, i.e., 25 from the left side of the first branch, then 25 shoots from the right side of the next branch.

Each shoot was evaluated individually and rated 1, 2, 3, or 4 to indicate degree of defoliation according to the following system:

Percent Defoliation	Rating
0 - 25	1
25 - 50	2
50 - 75	3
75 - 100	4

Hand tally counters were used to maintain a cumulative tally as each was examined. For example, if the first shoot was about 40 percent defoliated, the tally counter was punched twice; if the next was about 60 percent defoliated, the counter was punched three more times, and so on until all 25 shoots had been examined and classified. The cumulative total of ratings for each branch represented the estimated percent defoliation for the branch. A data form was designed which accommodated all defoliation estimates from a cluster.

Laboratory Procedures

Two branches per tree were used for egg mass counts. These were transferred to the laboratory and placed directly in cold storage until examined for the presence of eggs.

All needles, both attached and loose, were thoroughly examined. Needles containing egg masses, regardless of size or condition, were removed and placed in a container with a branch identification label. They were then examined microscopically by an experienced technician to determine if they were old, new, parasitized or non viable. This was recorded on a data form along with length of egg masses, and number of rows per egg mass. No criteria were established for separating old and new egg masses; this decision was based on the judgment of the technician.

Two methods of estimating foliage area were used: grid and length x width. In the grid method, each branch was clipped into 10-15 cm segments, arranged over a grid calibrated in centimeters, and the number of square centimeters covered was recorded. For the length x width method, direct measurements were taken in the field and recorded on the identification tag that accompanied each branch.

Analysis

Cluster level summaries. Data recorded on the forms were manually edited, coded, and keypunched by Regional personnel. Data files were created at the Fort Collins Computer Center (FCCC), and FIDM/MAG initiated computer edit runs, made corrections, and processed annual summaries. Summaries for egg mass density and defoliation were prepared for each entomological unit. Unit means and standard errors were computed from individual cluster means.

Egg Mass densities used in this report are expressed as the number of egg mass per square meter of foliage based on the length x width method. These data are also available for the "Grid" method, however since not all Regions used that method, a much larger data base was available by using the length x width method.

Defoliation estimates based on the four-class system were reduced by 12.5 percent to adjust the estimates to the midpoint of each class.

Other statistics generated by the summary programs included the following:

1. Egg mass densities per square meter based on the grid method of determining branch area where these data were available
2. Egg masses per branch
3. Viable egg masses per branch
4. Old egg masses per branch
5. Number of rows per mass
6. Egg mass length
7. Unadjusted defoliation estimates
8. Defoliation index

The following equations were used to compute cluster level means:

$$\text{Egg Mass Density}_i = \sum_{j=1}^{t} \left\{ \left(\sum_{k=1}^{b} \frac{EM_{ijk}}{(L_{ijk}\ W_{ijk})/2(10{,}000)} \right) /b \right\} /t$$

$$\text{Defoliation}_i = \sum_{j=1}^{t} \left\{ \left(\sum_{k=1}^{b} DEF_{ijk} \right) /b \right\} /t - 12.5$$

where i = cluster

j = tree

k = branch

t = number of trees per cluster

b = number of branches per tree

L = length of branch in centimeters

W = width of branch in centimeters

EM = new egg masses

DEF = defoliation

Entomological Unit Means. Cluster means were used to compute entomological unit means as follows:

$$\text{Egg Mass} = \frac{\sum_{i=1}^{m} EM_i}{m}$$

$$\text{Defoliation} = \frac{DEF_i}{m}$$

where m = number of clusters in an Entomological Unit

Relating egg mass densities to defoliation. Only data from Regions 1, 2, 3, and 4 were included in the analysis. R-6 data were not analyzed because they consisted primarily of "0" egg mass densities and the lowest levels of defoliation.

Generally, only those entomological units with data from 10 or more clusters were used in the analysis. We felt that in most cases, fewer than 10 data pairs (clusters with matching egg mass and defoliation) in a given year would not provide enough information upon which to make a prediction.

Three approaches were used to analyze the data: (1) comparing data collected in each Region by year of collection without regard to age of infestation; (2) combining all entomological unit summaries westwide; and (3) grouping all Regional data by age of the infestation. Linear, quadratic and cubic regression equations were computed for each approach using egg mass density and defoliation as the independent and dependent variables, respectively.

1. Analysis by year of data collection. Two separate data listings were made for each Region. The first data set included all clusters as follows:

1976 egg masses--1977 defoliation
1977 egg masses--1978 defoliation
1978 egg masses--1979 defoliation

The second data set included only those clusters containing matched data for all three years (table 1). The "All Data" columns show the total observed paired data and the "Matched" columns show just those clusters with data from all three years.

Table 1. Number of data pairs used for analysis - Regions 1-4, 1976-79.

Year	Region 1		Region 2		Region 3		Region 4	
	All data	Matched	All data	Matched	All data	Matched	All data	Matched
76-77	66	45	19	10	62	42	112	91
77-78	49	45	56	10	104	42	127	91
78-79	119	45	102	10	88	42	145	91
Total	234	135	177	30	254	126	384	273

Simple linear regression models (Y = A + BX) were computed for each Region's data set.

2. Analysis of entomological unit summary data. The entomological unit summaries were used to develop a linear regression model on a westwide basis. Of 56 unit summaries available for use in development of this model, 45 were used. The remaining 11, randomly selected from the original 56, were used to verify the model by computing a predicted defoliation from egg mass densities.

3. Analysis relative to age of infestations. The entomological units investigated during this project were in different stages of infestation. Some had been continuously defoliated for many years, while others were just beginning to show visible defoliation. We felt that infestation age might have a significant bearing on predictability, therefore data were sorted according to infestation age. Regional FIDM personnel provided this information for each entomological unit based on the year defoliation was first recorded for the unit on an aerial sketchmap. Infestation age was determined using the following formula:

$$IA = (X-Y) + 1$$

where IA = infestation age

X = year of current survey

Y = year defoliation first recorded on sketchmaps of the unit

Entomological units were sorted into five categories (table 2). Analyses were conducted for each Region and westwide by age and a series of predictive equations was developed.

Table 2. Reorganization of paired Entomological Unit data by infestation age.

Region	Entomological Unit	Age of Infestation (in years) 1	2	3	4	≥5
1	3-1					78-79
	11-1			76-77	77-78	78-79
	11-2			76-77	77-78	78-79
	11-3			76-77	77-78	78-79
	12-1					78-79
	12-2					78-79
	12-4					78-79
2	10-1			76-77	77-78	78-79
	10-2					78-79
	10-3					78-79
	12-1					77-78
						78-79
	12-2				77-78	78-79
	12-4					78-79
	12-7					78-79
3	2-13		77-78	78-79		
	2-16		76-77	77-78	78-79	
	3-8		76-77	77-78		
	3-15		76-77	77-78	78-79	
	6-4	76-77	77-78	78-79		
	7-7		76-77	77-78	78-79	
	10-5	76-77				
4	3-3			76-77	77-78	78-79
	12-50					77-78
						78-79
	13-4	76-77	77-78	78-79		
	13-80			78-79		
	15-1		76-77	77-78	78-79	
	15-2		76-77	77-78	78-79	

Evaluation of Prediction Accuracy

Since equations were based on both cluster level summaries and entomological unit summaries, two evaluation procedures were used.

For those equations based on cluster summaries, all individual cluster egg mass densities representing an entomological unit were entered into the equation being evaluated and used to calculate adjusted defoliation estimates. Each of these estimates was converted to the proper defoliation category (table 3) and an average predicted defoliation category determined for the entire unit. In the same manner, the actual adjusted defoliation recorded for each cluster egg mass density was converted to the proper category and the actual average defoliation category determined for the unit. These values were then compared to determine accuracy of prediction.

Table 3. Adjusted defoliation and defoliation categories.

Adjusted Defoliation (percent)	Defoliation Category
<12.5	1
12.5 - 37.5	2
37.5 - 62.5	3
>62.5	4

For the equation based on entomological unit summaries, the unit egg mass density was entered into the equation and a unit defoliation estimate computed. This estimated adjusted defoliation and the actual adjusted defoliation were converted to defoliation categories as above and compared to determine accuracy of prediction.

RESULTS

Evaluation of Equations Based on Year of Data Collection

Egg mass and defoliation statistics used to compute Regional linear predictive equations are presented in tables 4a-4d[2]. Regression models developed from these statistics are shown in tables 5a-5d.

The original intent of this project was to collect matching egg mass densities and defoliation estimates over a period of time to establish predictive equations. With this in mind, the accummulated experience over time, represented by the three-year combined regressions from each region, was evaluated using procedures described (tables 6a-6d).

2 Quadratic and cubic models were developed but are not presented. They did not improve predictions over the linear models and only added complexity.

Table 4a. Egg mass and defoliation statistics used in linear model (Table 5a) (R-1).

Year	n	Egg Mass Mean	S.E.	Smallest	Largest	Defoliation Mean	S.E.	Smallest	Largest
All Data									
76-77	66	35.3	3.5	.0	111.7	51.5	2.9	12.5	87.5
77-78	49	25.4	2.8	0.8	85.9	51.0	2.6	21.5	86.2
78-79	119	35.4	2.2	1.7	98.5	34.1	1.2	14.0	75.8
Combined	234	33.3	1.6	.0	111.7	42.5	1.3	12.5	87.5
Matched Data									
76-77	45	37.7	4.4	.0	111.7	54.2	3.2	12.5	87.5
77-78	45	26.4	3.0	0.8	85.9	51.6	2.6	21.5	83.1
78-79	45	34.6	3.4	5.6	89.6	34.5	2.1	15.0	75.8
Combined	135	32.9	2.1	.0	111.7	46.8	1.3	12.5	87.5

Table 5a. Linear regression model coefficients (R-1).

Year	n	Y = A + BX A	B	R^2	Sy·x
All Data					
76-77	66	33.24	.518	.378	18.85
77-78	49	39.70	.447	.222	16.47
78-79	119	29.16	.138	.061	12.85
Combined	234	33.06	.285	.124	18.53
Matched Data					
76-77	45	35.93	.484	.427	16.56
77-78	45	40.93	.406	.208	15.93
78-79	45	27.33	.207	.106	13.75
Combined	135	34.87	.362	.196	18.03

Table 4b. Egg mass and defoliation statistics used in linear model (Table 5b) (R-2).

Year	n	Egg Mass Mean	S.E.	Smallest	Largest	Defoliation Mean	S.E.	Smallest	Largest
All Data									
76-77	19	15.2	4.4	.0	58.1	48.2	5.4	12.5	87.5
77-78	56	9.8	1.0	.0	40.2	51.1	3.0	14.7	87.5
78-79	102	14.0	1.3	.0	62.5	49.2	2.1	12.5	87.2
Combined	177	12.8	1.0	.0	62.5	49.7	1.6	12.5	87.5
Matched Data									
76-77	10	6.7	2.2	.0	20.9	42.6	4.8	21.7	69.7
77-78	10	7.5	2.5	.0	21.3	41.4	6.8	17.5	72.5
78-79	10	8.3	3.0	1.1	26.7	29.9	4.3	12.5	51.6
Combined	30	7.5	2.5	.0	26.7	38.0	5.5	12.5	72.5

Table 5b. Linear regression model coefficients (R-2).

Year	n	Y = A + BX A	B	R^2	Sy·x
All Data					
76-77	19	41.37	.448	.136	22.39
77-78	56	44.83	.646	.049	21.84
78-79	102	39.04	.723	.219	18.39
Combined	177	41.78	.618	.137	19.92
Matched Data					
76-77	10	33.93	1.285	.341	13.18
77-78	10	43.27	-.251	.009	22.64
78-79	10	21.81	.975	.454	10.67
Combined	30	33.42	.605	.074	17.15

Table 4c. Egg mass and defoliation statistics used in linear model (Table 5c) (R-3).

Year	n	Egg Mass Mean	S.E.	Smallest	Largest	Defoliation Mean	S.E.	Smallest	Largest
All Data									
76-77	62	19.2	2.2	0.5	69.4	63.8	2.8	12.5	87.5
77-78	104	15.9	1.8	.0	103.2	41.2	2.5	12.8	87.2
78-79	88	20.3	2.5	.0	116.3	47.4	3.0	12.7	87.5
Combined	254	18.2	1.3	.0	116.3	48.9	1.7	12.5	87.5
Matched Data									
76-77	42	22.1	2.8	0.5	69.4	63.5	3.7	12.5	87.5
77-78	42	16.5	2.9	.0	85.4	35.2	3.7	12.8	86.3
78-79	42	18.4	3.6	.0	71.4	37.7	4.2	12.6	87.3
Combined	126	19.0	1.8	.0	85.4	45.5	2.5	12.5	87.5

Table 5c. Linear regression model coefficients (R-3).

Year	n	Y = A + BX A	B	R^2	Sy·x
All Data					
76-77	62	47.50	.849	.432	16.65
77-78	104	28.17	.820	.363	20.18
78-79	88	30.89	.812	.445	21.20
Combined	254	34.32	.797	.365	21.54
Matched Data					
76-77	42	43.70	.895	.479	17.38
77-78	42	20.70	.881	.478	17.34
78-79	42	19.64	.984	.720	14.61
Combined	126	26.71	.988	.517	19.47

Table 4d. Egg mass and defoliation statistics used in linear model (Table 5d) (R-4).

Year	n	Egg Mass Mean	S.E.	Smallest	Largest	Defoliation Mean	S.E.	Smallest	Largest
All Data									
76-77	112	17.5	2.2	.0	90.3	29.8	1.8	12.6	87.5
77-78	127	10.7	1.3	.0	70.8	29.5	3.7	12.5	84.2
78-79	145	19.7	1.9	.0	102.8	35.5	1.8	13.1	87.5
Combined	384	16.1	1.1	.0	102.8	31.9	1.0	12.5	87.5
Matched Data									
76-77	91	17.5	2.4	.0	90.3	27.3	1.6	12.6	72.4
77-78	91	12.2	1.8	.0	70.8	32.1	2.1	12.5	84.2
78-79	91	20.9	2.6	.0	102.8	36.3	2.3	13.1	87.5
Combined	273	16.9	1.3	.0	102.8	31.9	1.2	12.5	87.5

Table 5d. Linear regression model coefficients (R-4).

Year	n	Y = A + BX A	B	R^2	Sy·x
All Data					
76-77	112	24.18	.323	.161	17.13
77-78	127	19.06	.981	.614	12.05
78-79	145	27.71	.396	.181	19.33
Combined	384	24.19	.478	.254	17.33
Matched Data					
76-77	91	20.56	.387	.343	12.52
77-78	91	20.37	.960	.645	12.26
78-79	91	28.94	.353	.164	20.02
Combined	273	23.74	.484	.300	16.49

Table 6a. Predicted defoliation vs. actual defoliation (R-1).

Entomological Unit	Number Clusters	Predicted Defoliation Category	Actual Defoliation Category
3-1 (78-79)	9	2	2
11-1 (76-77)	12	3	3
(77-78)	9	2	3
(78-79)	15	2	2
11-2 (76-77)	18	2	3
(77-78)	15	2	3
(78-79)	18	2	2
11-3 (76-77)	9	2	3
(77-78)	7	2	2
(78-79)	17	3	2
12-1 (78-79)	20	2	2
12-2 (78-79)	16	2	2
12-4 (78-79)	9	2	2

Table 6b. Predicted defoliation vs. actual defoliation (R-2).

Entomological Unit	Number Clusters	Predicted Defoliation Category	Actual Defoliation Category
10-1 (76-77)	7	3	2
(77-78)	21	3	3
(78-79)	18	3	3
10-2 (78-79)	20	3	3
10-3 (78-79)	10	3	2
12-1 (77-78)	13	3	2
(78-79)	7	3	2
12-2 (77-78)	21	3	3
(78-79)	12	3	3
12-4 (78-79)	10	3	2
12-7 (78-79)	13	3	2

Table 6c. Predicted defoliation vs. actual defoliation (R-3).

Entomological Unit	Number Clusters	Predicted Defoliation Category	Actual Defoliation Category
2-13 (77-78)	20	2	2
(78-79)	19	2	3
2-16 (76-77)	10	3	4
(77-78)	20	3	3
(78-79)	20	3	3
3-8 (76-77)	12	2	3
(77-78)	16	2	2
3-15 (76-77)	10	2	3
(77-78)	20	2	2
(78-79)	16	2	2
6-4 (76-77)	10	2	3
(77-78)	10	2	2
(78-79)	10	2	2
7-7 (76-77)	10	2	3
(77-78)	19	3	3
(78-79)	19	3	3
10-5 (76-77)	10	3	3

Table 6d. Predicted defoliation vs. actual defoliation (R-4).

Entomological Unit	Number Clusters	Predicted Defoliation Category	Actual Defoliation Category
3-3 (76-77)	28	2	2
(77-78)	34	2	2
(78-79)	29	2	2
12-50 (77-78)	20	2	2
(78-79)	17	2	2
13-4 (76-77)	19	2	2
(77-78)	19	2	2
(78-79)	18	2	2
13-80 (78-79)	20	2	2
15-1 (76-77)	27	2	2
(77-78)	27	2	2
(78-79)	25	2	3
15-2 (76-77)	25	2	2
(77-78)	24	2	2
(78-79)	22	2	2

After the regional equations were developed, the data were rearranged by year of collection to show individual years equations (tables 5a-5d). Examination of the individual regressions by analysis of covariance demonstrated some differences in both slope and Y intercept (table 7). This indicated that year is a significant sampling variable and that idea led to the grouping of data by age of infestation.

Table 7. Results of analysis of covariance.

Statistical Test	Region 1	Region 2	Region 3	Region 4
Number of data sets	3	3	3	3
Observations per set	45	10	42	91
F test for common slope	NS	NS	NS	**
F test for single regression	**	NS	**	**
Analysis of covariance testing defoliation	**	NS	**	**

NS = not significant ** = significant (.01)

Evaluation of Single Westwide Equation

The form of the model that provided the best fit for this equation was Y = A + B (ln X). The resultant equation was:

$$Y = 15.8 + 10.14 \text{ (natural log of X)}$$

The coefficient of determination (r^2) was .319 and Sy·x was 13.85

As stated, this model was based on 45 of 56 available data sets. The remaining 11 data sets were used for model verification on the basis of predicted adjusted defoliation category versus actual adjusted defoliation category (table 8).

Table 8. Verification of single westwide equation.

Egg Mass Density (per m^2)	Actual Defoliation	Actual Defoliation Rating	Predicted Defoliation	Predicted Defoliation Rating
23.2	36.5	2	47.7	3
31.6	29.4	2	50.8	3
1.7	24.9	2	21.2	2
24.6	31.1	2	48.3	3
15.1	61.9	3	43.3	3
17.0	74.1	4	44.5	3
2.1	15.7	2	23.3	2
11.1	58.2	3	40.2	3
2.1	15.6	2	23.3	2
3.5	14.4	2	28.5	2
8.8	38.6	3	37.9	3

The verification indicated that this model will allow correct prediction into one of four defoliation categories 7 out of 11 times.

Evaluation of Equations Based on Age of Infestation

Linear model coefficients, all in the form $Y = A + BX$ were developed for each Region by age of infestation (table 9). Missing equations indicate that no entomological units for a given infestation age class occured in that Region.

Linear model coefficients for a combined westwide equation based on similarly aged infestations are shown in table 10.

Table 9. Linear model coefficients by age of infestation.

Age of Infestation (in years)	Number Clusters	A	B	R^2	Sy·x
Region 1					
3	39	36.22	.516	.538	14.85
4	31	46.58	.349	.149	17.74
≥5	100	28.75	.154	.070	13.28
Region 2					
3	7	28.93	1.009	.667	12.94
4	41	46.56	1.274	.163	18.15
5	103	36.42	.833	.255	18.60
Region 3					
1	20	53.36	.899	.273	13.09
2	72	34.99	1.037	.380	21.78
3	104	28.92	.919	.415	20.55
4	54	26.64	.873	.598	17.13
Region 4					
1	19	15.18	4.640	.729	5.44
2	71	18.26	.416	.521	8.94
3	116	24.34	.410	.242	15.08
4	81	25.64	.829	.522	15.85
5	65	21.79	.316	.151	18.38

Table 10. Linear model coefficients by age of infestations (all Regions).

Age of Infestation (years)	n	A	B	R^2	Sy·x
1	39	26.13	2.347	.631	16.03
2	143	27.54	.719	.295	21.93
3	266	27.57	.622	.387	19.08
4	207	34.87	.692	.339	19.51
5	268	34.27	.156	.032	19.76

Each equation was evaluated by computing defoliation based on individual cluster egg mass densities using the proper equation by age of the infestation in the entomological unit (tables 11a-11d).

Table 11a. Predicted average defoliation category based on age of infestation vs. actual average defoliation category (R-1).

E.U.	Date	Age of Infestation (in years)	n	Regional Predicted Defol. Category	Westwide Predicted Defol. Category	Average Actual Defol. Category
3-1	78-79	5	10	2	2	2
11-1	76-77	3	12	3	3	3
	77-78	4	9	3	3	3
	78-79	5	15	2	2	2
11-2	76-77	3	18	3	3	3
	77-78	4	15	3	3	3
	78-79	5	18	2	2	2
11-3	76-77	3	9	3	2	3
	77-78	4	7	3	3	2
	78-79	5	14	2	2	2
12-1	78-79	5	20	2	2	2
12-2	78-79	5	14	2	2	2
12-4	78-79	5	9	2	2	2

Table 11b. Predicted average defoliation category based on age of infestation vs. actual average defoliation category (R-2).

E.U.	Date	Age of Infestation (in years)	n	Regional Predicted Defol. Category	Westwide Predicted Defol. Category	Average Actual Defol. Category
10-1	76-77	3	7	2	2	2
	77-78	4	20	3	2	3
	78-79	5	18	3	2	3
10-2	78-79	5	20	3	2	3
10-3	78-79	5	10	2	2	2
12-1	77-78	5	13	2	2	2
	78-79	5	7	2	2	2
12-2	77-78	4	21	3	2	3
	78-79	5	12	3	2	3
12-4	78-79	5	10	2	2	2
12-7	78-79	5	13	3	2	2

Table 11c. Predicted average defoliation category based on age of infestation vs. actual average defoliation category (R-3).

E.U.	Date	Age of Infestation (in years)	n	Regional Predicted Defol. Category	Westwide Predicted Defol. Category	Average Actual Defol. Category
2-13	77-78	2	20	2	2	3
	78-79	3	19	2	2	3
2-16	76-77	2	10	3	3	4
	77-78	3	20	2	2	3
	78-79	4	20	3	3	3
3-8	76-77	2	12	3	2	3
	77-78	3	16	2	2	2
3-15	76-77	2	10	3	2	3
	77-78	3	20	2	2	2
	78-79	4	16	2	2	2
6-4	76-77	1	10	3	2	3
	77-78	2	10	3	2	2
	78-79	3	10	2	2	2
7-7	76-77	2	10	3	2	3
	77-78	3	19	3	2	3
	78-79	4	18	2	3	3
10-5	76-77	1	10	3	3	3

Table 11d. Predicted average defoliation category based on age of infestation vs. actual average defoliation category (R-4).

E.U.	Date	Age of Infestation (in years)	n	Regional Predicted Defol. Category	Westwide Predicted Defol. Category	Average Actual Defol. Category
3-3	76-77	3	28	2	3	2
	77-78	4	34	2	3	2
	78-79	5	28	2	2	2
12-50	77-78	5	20	2	2	2
	78-79	5	17	2	2	2
13-4	76-77	1	19	2	2	2
	77-78	2	19	2	2	2
	78-79	3	18	2	2	2
13-80	78-79	3	19	2	2	2
15-1	76-77	2	27	2	2	2
	77-78	3	27	2	2	2
	78-79	4	25	2	3	3
15-2	76-77	2	25	2	2	2
	77-78	3	24	2	2	2
	78-79	4	22	2	2	2

Using the results of the evaluations presented in tables 6a-6d, 11a-11d, and those found by evaluating all entomological units using the single westwide equation, a probability of correct prediction matrix was developed (table 12).

Table 12. Probability of correctly predicting defoliation using various prediction equations.

Equation	Number of Entomological Units	No. Predicted Correctly	Percent Correct
Regional Simple Linear	56	38	67.9
Single Westwide	56	33	58.9
Regional, Aged	56	47	83.9
Westwide, Aged	56	38	67.9

These results indicate consistently low levels of predictability using all equations except those developed on a Regional basis that consider infestation age.

The Single Westwide Equation developed from the entire data base, represents the most general of the equations, and thus would be expected to be the poorest predictor. The various Regional linear equations and the westwide aged equation are also general, but since they represent four and five equations respectively to predict the same values predicted by the single equation, it would be expected that there would be an increase in the probability of a correct prediction. The same argument can be used in discussing the Regional Aged Equations. These 15 equations were developed from data sub-units that produced the westwide aged equation and would be expected to be better predictors than the single equation.

The relative success of making a correct prediction by region and age of infestation is shown in table 13.

Table 13. Probability of correctly predicting defoliation on Entomological Units using Regional equations based on infestation age.

Age of Infestation (in years)	Region[1] 1	2	3	4	Total All Regions
1	-	-	2/2	1/1	3/3
2	-	-	3/6	3/3	6/9
3	3/3	1/1	4/6	5/5	13/15
4	2/3	2/2	2/3	2/3	8/11
≥5	7/7	7/8	-	3/3	17/18
Total by Region	12/13	10/11	11/17	14/15	47/56

1 No. Correctly Predicted/Total No. Predicted

CONCLUSIONS

Based on the results of this evaluation, the following conclusions can be drawn:

1. Substantial variability exists in the relationship between egg mass density and subsequent defoliation caused by western spruce budworm in Douglas-fir both within and between Forest Service Regions in the West.

2. Using equations developed from the existing data base, defoliation on entomological units within Regions can be predicted into the correct defoliation category 8 out of 10 times when the age of the infestation being evaluated is known.

3. Examination of the intercepts of all equations developed shows that it is impossible to predict into defoliation category 1. This is due to the definition of the defoliation categories. Categories 2, 3, and 4 represent ranges of defoliation ratings within which all possible numbers represented by those categories can occur. Category 1, however, can only be represented by a single number, the highest value within the category, and therefore does not represent a range.

4. There is a substantial amount of variability in predicting defoliation that remains unexplained. Physical characteristics of cluster locations have been shown to be quite useful in hazard rating stands in regard to the Douglas-fir tussock moth (Stoszek 1977, and Heller and Miller 1977) and should be examined to attempt to explain some of this variability.

RECOMMENDATIONS

We recommend that:

1. Regions determine the relative age of infestations and utilize the appropriate equations presented in table 9 as predictors of defoliation. Where specific equations have not yet been developed for a Region, it is recommended that the appropriate equation presented in table 10 be used until a Region-specific equation can be developed.

2. Use data collection and analysis procedures that conform to this publication in future egg mass surveys.

3. Examine physical site characteristics of the clusters to determine their effect on defoliation prediction.

4. If Regions continue to collect data to refine these predictive equations, it is recommended that the following change in evaluating defoliation be made:

Percent Defoliation	Rating
none visible	0
Trace-25	1
25-50	2
50-75	3
75-100	4

The addition of a "0" category will allow category 1 to represent a range of defoliation. This should result in revising the Y-intercepts downward, thus allowing prediction into category 1 and producing a model that more accurately reflects the true situation on the entomological unit.

LITERATURE CITED

Carolin, V.M. and W.K. Coulter. 1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. USDA Forest Service, Res. Pap. PNW-149. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 38 pp.

Grimble, D.G. and R.W. Young. 1977. Western spruce budworm egg mass-defoliation surveys. A working group progress report. USDA Forest Service MAG Rpt. No. 77-3. Forest Insect and Disease Management, Methods Application Group, Davis, California. 21 pp.

Heller, R.C. and W.A. Miller. 1977. Color infrared photos define site conditions favorable for Douglas-fir tussock moth outbreaks. In Proceedings, Sixth Biennial Workshop on Aerial Color Photography in the Plant Sciences and Related Fields, August 9-11, 1977, Colorado State University, Ft. Collins, Colorado. pp. 43-52.

McKnight, M.E., J.F. Chansler, D.B. Cahill, and H.W. Flake. 1970. Sequential plan for western spruce budworm egg mass surveys in the central and southern Rocky Mountains. USDA Forest Service, Res. Note RM-174. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado. 8 pp.

Stoszek, K.J. 1977. Factors influencing tree and stand susceptibility to Douglas-fir tussock moth attack. Bull. Entomol. Soc. Amer. 23(3): 171-72.

APPENDICES

APPENDIX 1

WESTERN SPRUCE BUDWORM
EGG MASS-DEFOLIATION SURVEY
Egg Mass Data Form

Survey Code (1-3)	Form (4)	Year (5-6)	Region (7-8)	Host (9-10)	Forest (11-12)	Unit (13-14)	Cluster (15-17)
222	2						

TREE	BRANCH	Length cm	Width cm	Grid Area cm^2	New Egg Masses			Egg Viability		Old Egg Masses
					Number	Rows	Length mm	"Good" >50%	"Bad" >50%	
18		19-21	22-24	25-29	30-32	33-35	36-38	39-41	42-44	45-47
1	1									
	2	49-51	52-54	55-59	60-62	63-65	66-68	69-71	72-74	75-77
18		19-21	22-24	25-29	30-32	33-35	36-38	39-41	42-44	45-47
2	1									
	2	49-51	52-54	55-59	60-62	63-65	66-68	69-71	72-74	75-77
18		19-21	22-24	25-29	30-32	33-35	36-38	39-41	42-44	45-47
3	1									
	2	49-51	52-54	55-59	60-62	63-65	66-68	69-71	72-74	75-77

COMMENTS_____

_____

Date_____ Prepared by_____

APPENDIX 2

WESTERN SPRUCE BUDWORM
EGG MASS-DEFOLIATION SURVEY
Defoliation Survey Data Form

Survey Code (1-3)	Form (4)	Year (5-6)	Region (7-8)	Host (9-10)	Forest (11-12)	Unit (13-14)	Cluster (15-17)
222	3						

Tree	Branch	Defoliation	Comments
	1	(21-25)	
1	2	(26-30)	
	3	(31-35)	
	4	(36-40)	
	1	(41-45)	
	2	(46-50)	
2	3	(51-55)	
	4	(56-60)	
	1	(61-65)	
	2	(66-70)	
3	3	(71-75)	
	4	(76-80)	

COMMENTS_____

_____

Date_____Prepared by_____

APPENDIX 3

Raw cluster level data.

Northern Region (R-1) Douglas-fir

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
2	1	1	7.4						
		3	43.5	119.6			66.4		
2	2	2	33.5	15.7			29.9		
		4	20.6	2.0			16.2		
		5	1.9	.0			14.5		
		7	1.7	4.7			13.6		
		8	0.8	1.0			15.6		
2	3	7	10.4						
2	4	1	24.0						
		3	2.1	9.5			23.2		
2	5	3	80.6	47.4			53.2		
		4	5.6	5.4			25.3		
3	1	1		5.1			62.4		
		2	66.7	22.1	59.8		31.2	38.7	33.2
		3	41.4				18.8		
		4			18.6			39.8	29.9
		5	68.1	29.3	32.1		54.7	53.4	36.7
		6							
		7							
		8	14.1	26.6	16.7		56.3	46.7	23.0
		9	.0	9.4	7.0		22.7	35.3	24.7
		10	13.0	15.1	13.6		55.7	42.3	39.4
		11	10.6	7.1	17.0		22.7	55.1	31.7
		12			24.3			69.7	72.3
		13			26.5			29.6	19.6
		14			16.8			69.7	54.3

Northern Region cont'd.

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
3	2	2			13.8			47.2	33.4
		3			14.5			48.4	29.0
		5	33.3						
		7	27.5		22.6			59.3	33.2
		8	14.2		27.2			48.0	31.6
		10			17.8			59.7	20.7
		11			45.7			71.4	38.7
		12			20.9			34.8	31.3
		13			12.3			54.7	30.2
		14			31.6			52.1	23.8
11	1	1	68.5	28.7	26.7		70.2	86.2	
		2	23.4	85.9	89.6		22.4	80.2	66.7
		3	50.2	56.6	33.0		80.2	43.2	17.2
		4	60.4	40.6			77.7		
		5	31.0	13.3	30.7		49.2	27.7	
		6							
		7	0.8	1.1	31.6		23.3	47.3	38.9
		8	89.2	16.9	31.1		77.1		29.3
		9	96.8	74.7			85.5		
		10	111.7	30.8	15.1		87.5	82.7	34.7
		11	56.4	13.7	9.7		78.6	68.2	47.4
		12	78.1	26.2	26.7		73.4	68.8	22.1
		13	59.9	40.5	58.0		80.3	82.0	31.4
		18			57.6			85.0	21.0
		20			35.0			42.4	14.0
		21			39.5			53.2	16.2
		22			44.3			82.7	40.4
		23			21.1			49.3	18.4
		24			53.0			39.5	17.7
		25			36.9			70.6	21.5

Northern Region cont'd.

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
11	2	1	11.3	20.4	5.8		60.2	61.8	18.7
		2	24.0	2.2	6.9		30.3	36.0	24.8
		3	75.6	48.7	30.9		67.2	44.4	23.8
		4	51.8	31.3	49.3		40.7	44.8	29.3
		5	43.0	24.2	29.5		58.2	60.2	44.2
		6	41.4	36.2	61.6		49.7	63.5	63.4
		7	21.7	16.3	8.1		66.2	83.1	75.8
		8	65.2	100.00			48.4		50.2
		9	56.5	66.6	78.1		45.4	58.7	21.8
		10	64.8	14.5	14.5		85.9	78.7	21.9
		11	105.0	36.0	24.0		83.2	75.7	27.9
		12	89.3	52.2	67.3		72.9	64.5	38.4
		13	26.4	33.6	40.2		55.3	60.9	28.1
		14	27.0	28.0	30.6		67.2	62.7	23.9
		15	12.6	9.3	5.6		42.7	32.6	15.0
		16	27.9	25.5			54.5		49.0
		17	9.4						
		18	1.6	5.0	19.2		12.5	55.0	51.8
		19	54.8	24.7	46.9		79.1	59.0	41.7
		21			68.2			63.8	33.8
		22			31.1			45.4	33.8
11	3	1	55.7	44.5			87.5		
		2	95.4	29.4			87.5		35.9
		3	42.8	50.1	48.5		87.1	68.9	54.6
		4							
		5	42.6	55.5	50.6		69.9	61.8	55.5
		6	87.9	37.1	51.8		79.0	35.7	24.7
		7	15.2	15.8	38.1		63.4	26.9	26.8
		8	11.2	0.8	80.0		36.7	29.7	47.8
		9	6.7	0.9	55.5		34.1	41.5	54.8
		10	18.9	15.0	55.6		24.3	23.6	28.4

Northern Region cont'd.

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
11	3	11	59.8		101.7			36.1	50.7
		12			108.0			50.8	25.5
		13			47.3			40.3	16.9
		14			19.7			76.0	46.2
		15			280.8			41.1	33.6
		16							
		17			56.4			52.2	40.1
		18			23.9			25.2	38.1
		19			67.7			52.7	29.8
		20			3.4			36.8	37.2
		21			98.5			53.8	47.9
		22							54.7
		23			113.0			53.2	
12	1	1	7.3	1.9	6.7		24.1	23.6	15.5
		2							
		3	18.9	5.8	15.8		58.6	37.3	26.6
		4							
		5							
		6							
		7							
		8	24.7	50.1	26.0		61.9	38.4	43.8
		9							
		10							
		11			34.3			41.8	45.7
		12	37.7	27.9	44.4		46.6	48.3	43.4
		13							
		14			37.3			65.5	61.5
		15			22.1			36.5	30.2
		16			25.8			44.4	25.2
		17			49.8			36.0	23.9
		18			49.3			72.5	47.6

Northern Region cont'd.

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
12	1	19			41.4			42.6	39.3
		20			77.5			55.3	43.8
		21			72.5			52.7	46.5
		22			35.2			27.7	43.5
		23			9.4			36.2	22.1
		24			68.6			70.2	41.8
		25			61.8			52.2	59.2
		26			13.8			34.0	27.7
		27			48.5			30.4	30.4
		28			2.8			28.1	16.2
12	2	1	5.1	4.7	18.0		42.4	40.8	31.8
		2							
		3	43.2	27.5	59.4		42.0	22.0	29.2
		7			95.1			38.8	36.1
		9			12.6			26.3	16.2
		10			77.5			46.2	51.9
		11			18.6			18.5	20.6
		12			26.1			27.2	37.9
		13			2.1			35.7	40.2
		14			17.1			43.2	24.0
		15			3.6			25.2	23.6
		16			116.3			57.2	58.1
		17			24.2			28.1	48.0
		18			125.2			55.2	34.1
		19			90.0			20.7	25.9
		20			20.4			26.7	49.5
		22			39.5			52.1	40.3
12	3	2							
		3	2.0	5.6	7.8		35.2	37.3	
		4			27.5			57.9	
		5	46.7	25.5	53.0		52.2	48.3	20.7

Northern Region cont'd.

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
		6							
		10							
		11	.0	1.3	6.2		26.0	21.5	16.7
		12							
		13			81.5			49.2	39.2
		14			12.1			34.4	
		15			18.5			28.5	20.6
		16			7.7			41.7	
		17			63.2			81.3	38.7
12	4	2			24.1			63.7	
		5	10.9	9.6	39.1		14.9	26.2	37.0
		6			20.2			42.2	29.9
		10	27.1	52.8	18.0		83.2	69.4	34.4
		11			44.8			63.3	17.9
		12			62.9			37.5	43.9
		13			53.6			45.4	19.1
		14			4.3			32.7	15.8
		15			27.2			20.7	40.8
		16			14.7			77.7	25.6

Rocky Mountain Region (R-2) Douglas-fir

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
10	1	1	3.4	.0	.0		35.1	67.3	
		2	.0	1.7	1.1	5.4	36.7	69.2	31.5
		3	4.5	.0			18.0		
		4	3.3	.0	1.1	1.1	21.7	17.5	24.9
		5	2.4	2.8	5.6	13.0	28.0	28.8	12.5
		6	43.1	23.4	69.7		76.7	87.5	
		7	4.6	6.6	8.2	7.0	53.7	68.8	38.6
		8	1.3	.0			12.5		
		9		9.6	23.4	25.0		70.9	43.8
		10		17.2	8.3	1.8		79.2	42.1
		11		16.6	25.2	16.8		87.5	87.5
		12		3.3	7.2	13.4		19.2	32.7
		13		40.2	27.9	10.8		25.4	19.6
		14		3.9	7.0	8.2		44.0	41.2
		15		9.7	13.3	18.7		25.2	49.4
		16		15.6	5.8	34.7		49.7	44.2
		17		17.7	15.4			53.2	
		18		13.3	4.6			43.9	
		19		16.1	18.7			64.1	
		20		15.9	26.2	31.1		87.5	80.2
		21		16.0	7.3	18.2		40.9	54.5
		22		13.7	40.6	32.1		75.9	74.2
		23		18.5	29.8	41.1		84.6	83.8
		24			16.0				
		25			12.3				
		26			51.9	61.2			86.7
		27			4.0	.0			43.2
		28			21.7				

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
10	2	1			18.9	42.0		57.3	71.9
		2			20.9	92.0		67.7	64.3
		3			32.9	19.8		57.1	87.3
		4			18.0	34.7		80.2	82.6
		5			32.3	51.5		69.2	53.0
		6			28.5	43.0		50.0	72.2
		7			1.5	32.7		87.5	85.3
		8			21.4	97.9		86.2	52.7
		9			17.4	33.4		76.6	75.7
		10			10.2	23.5		82.2	57.5
		11			5.7	67.0		86.1	76.8
		12			9.2	11.2		87.5	87.2
		13			9.1	23.1		87.5	81.3
		14			17.2	19.0		87.5	69.7
		15			30.4	20.8		87.5	77.8
		16			5.8	2.4		87.5	87.2
		17			13.7	3.9		87.5	70.3
		18			20.6	60.8		85.0	57.8
		19			11.3	77.3		62.2	65.4
		20			37.3	67.3		51.5	61.5
10	3	1			3.0	7.8		21.2	30.4
		2			4.9	6.4		26.0	34.4
		3			4.3	3.7		28.4	43.1
		4			1.2	22.4		33.8	31.3
		5			12.1	18.0		28.1	20.9
		6			6.3	2.9		35.0	38.8
		7			5.1	4.9		41.6	68.8
		8			11.9	6.0		31.7	32.2
		9			5.6	13.3		50.0	60.0
		10			4.4	5.7		24.2	31.3

Rocky Mountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
10	4	3				24.2			82.7
		4				25.2			76.0
		5				22.9			57.1
		6				24.0			86.0
		7				19.7			58.1
12	1	1	42.6	5.7			87.5		
		2	11.0	1.0	1.8		84.9	27.7	
		3		2.8	.0	49.3	38.2	33.6	17.2
		4	15.4	20.5	2.2	.0	57.1	19.7	19.2
		5		6.8	2.0	21.2		17.2	38.2
		6		.0	.0	7.0		14.7	16.0
		7		3.5	4.8				
		8		10.5				41.1	
		9		10.0	1.4			49.8	
		10	2.3	4.5			84.1	42.4	
		11		3.4	4.1	2.5		23.7	46.6
		12	20.9	21.3	2.3	6.0	54.4	37.9	23.6
		13	8.8	2.3	1.1	4.5	69.7	21.2	13.4
		14	16.8	6.0				25.4	
		15		4.4	.0			17.1	
		77						36.5	
12	2	1		12.7	45.5			60.5	
		2		2.1	47.8			70.8	
		3		7.0				64.7	
		4		6.5	1.6	16.6		36.8	25.9
		5		5.6	15.0	41.7		66.3	63.9
		6		12.5				49.9	
		7		8.7	26.0			64.8	
		8		9.2	53.3	4.0		85.6	82.4
		9		13.5	64.0			61.1	

Rocky Mountain cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
12	2	10	2.3	10.4	11.5	13.8	39.7	36.4	51.6
		11	58.1	7.1		22.1	39.2	63.7	46.0
		12	9.7	.0	26.7	11.2	33.2	42.0	48.2
		13	.0	9.1	22.8	19.4	31.7	72.5	35.2
		14		10.9			40.7	31.6	
		15		1.0	27.5	22.4		63.4	58.7
		16		10.3	23.2	8.2		82.2	65.6
		17		23.5	45.6		41.9	81.3	61.5
		18	54.5	12.4	16.9		51.4	56.7	
		19		12.2	7.1	37.4		62.1	69.0
		20		8.6	33.9	22.5		40.9	43.6
		21		4.0	31.5	35.1		71.6	79.7
12	3	1			1.2	5.7		39.2	30.5
		2			8.0	10.1		44.6	38.0
12	4	1			3.6	2.5		53.3	69.0
		2			3.8	2.7		32.7	54.4
		3			6.9	3.4		31.4	52.6
		4			7.5	6.2		30.8	40.2
		5			1.7	.0		29.2	30.4
		6			5.5	.0		32.2	30.2
		7			0.9	8.1		21.4	19.8
		8			1.3	1.4		35.3	31.8
		9			.0	.0			25.0
		10			6.0	.0		32.4	30.1
		11			3.8			44.8	
		12			3.9			32.7	
		13			0.9				
12	5	1			0.8	1.0			64.6
		2			8.5	1.4			28.5

Rocky Mountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
12	5	3			1.1	.0		40.8	36.2
		4			1.8	1.0		30.2	42.2
		5			1.1	0.8		30.2	28.7
12	6	1			12.6	6.7		33.3	30.2
		2			15.1	25.3		46.3	61.3
		3			40.8	25.6		55.8	65.1
		4			34.8	22.4		31.7	29.1
		5			17.4	16.0		38.2	32.7
		6				36.3			33.0
		7				27.9			55.2
		8				13.9			25.7
		9				58.9			57.2
		10				55.9			52.2
		11				26.1			44.7
		12				33.1			54.8
		13				58.1			35.3
		14				6.5			30.2
		15				15.6			37.2
12	7	1			3.8	9.3		16.7	54.7
		2			11.1	0.9		32.2	39.5
		3			15.5	5.2		18.8	23.6
		4			6.0	7.8		55.5	68.0
		5			1.7	1.4		20.8	29.6
		6			27.7	17.8		53.1	57.9
		7			62.5	30.3		44.5	61.2
		8			11.7	24.3		23.3	36.4
		9			26.2	13.2		52.0	31.3
		10			9.4	11.3		42.0	34.5
		11			21.6	15.6		42.2	43.9
		12			6.6	2.0		59.7	43.2

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
		13			17.2	7.6		37.0	41.2
		14				.0			29.0
		15				6.1			35.4
		16				15.5			27.4
		17				16.6			62.7
		18				15.0			33.7
		19				1.8			17.6
		20				12.2			24.0
		21				7.3			28.1
		22				9.2			32.0
		23				18.1			31.7
		24				1.7			41.5
		25				3.1			30.3
12	8	1				2.7			68.7
		2				2.5			63.2
		3				1.3			37.9
		4				1.8			36.9
		5				1.4			54.6
		17				9.2			

Southwestern Region (R-3) Douglas-fir

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
2	13	1		18.8	25.4	33.8		84.5	75.0
		2		31.9	12.4	39.2		25.5	53.1
		3		10.7	42.2	68.0		66.1	67.8
		4		10.7	24.3	36.0		69.1	63.4
		5		0.7	.0	3.2		21.2	16.7
		6		3.8	3.2	63.2		20.6	81.8
		7		.0	0.9	15.9		15.7	25.3
		8		3.3	5.7	87.8		17.2	65.2
		9		10.4	8.5	115.8		14.8	84.8
		10		2.1	7.9	11.0		16.6	26.6
		11		.0	.0	.0		38.3	24.0
		12		18.2	21.1	91.6		18.2	77.5
		13		6.6	13.2	52.8		35.7	87.5
		14		9.7	33.4	21.9		65.2	
		15		14.6	41.3	40.9		75.7	83.6
		16		7.3	14.1	25.2		82.7	85.2
		17		24.9	42.0	38.5		81.3	86.3
		18		12.1	22.0	52.2		61.5	80.6
		19		8.9	13.3	32.1		76.7	86.2
		20		2.8	27.9	33.8		50.3	87.4
2	16	1	53.4	30.8	39.5	78.2	87.5	33.3	80.2
		2	50.9	73.4	65.9	36.7	82.8	73.4	65.7
		3	20.7	30.1	23.9	36.9	62.8	58.3	46.2
		4	56.7	46.1	71.4	10.2	87.2	64.7	70.9
		5	17.4	21.8	71.3	89.1	73.7	59.4	76.7
		6	36.9	26.6	44.8	52.2	83.6	65.9	64.9
		7	49.3	19.1	46.6	157.2	83.6	36.2	76.1
		8	44.9	19.3	6.6	21.2	87.2	25.7	34.9
		9	37.9	32.5	25.6	30.5	86.6	78.8	57.7

Southwestern Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
2	16	10	12.6	3.9	14.2	21.8	80.1	53.9	50.1
		11		16.5	39.4	16.8		73.1	86.3
		12		33.6	46.9	27.2		67.7	70.2
		13		6.9	6.7	16.7		65.4	80.4
		14		8.9	26.7	32.7		65.7	70.5
		15		8.1	12.4	26.0		34.2	71.3
		16		20.8	83.1	15.2		50.5	79.6
		17		24.2	35.6	104.3		68.2	46.6
		18		14.3	44.7	53.3		33.6	85.2
		19		6.5	1.0	2.0		31.1	42.1
		20		2.0	18.9	27.5		52.6	55.8
3	8	1	18.5	21.0	5.1	20.5	80.2	20.7	25.0
		2	0.9	2.4		1.5	20.8		14.7
		3	8.3	7.4		8.6	45.1		17.3
		4	19.7	15.0			65.8		
		5	2.0	22.1	2.4	15.0	53.3	43.6	
		6	7.9	17.9	4.0	7.0	41.7	24.4	16.2
		7	2.9	11.7	23.8	28.2	64.2	39.0	
		8	6.0	4.4	2.4	22.7	58.2	27.7	
		9	6.8	26.1	9.9	54.8	64.7	51.9	
		10	38.4	34.0	41.4	114.9	87.0	57.6	
		11	32.5	17.1	16.5	74.1	84.2	42.5	60.4
		12	69.4	18.7	40.6	60.6	86.1	24.2	62.9
		13		8.3	13.1			22.2	
		14		17.8	.0			39.0	
		15		9.0	35.4			22.5	
		16		5.0					
		17		6.6	.0			38.9	
		18		3.7	.0			23.6	
		19		27.6	29.2			42.2	
		20		26.5	49.8			55.9	

Southwestern Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
3	15	1	5.5	7.7	4.6	42.9	15.3	24.4	13.7
		2	0.5	1.1	1.1	1.1	21.7	13.2	12.7
		3	32.6	6.1	4.9	14.0	70.6	20.5	28.2
		4	37.6	3.7	2.8	3.8	86.7	13.7	12.9
		5	4.6	.0	1.2	.0	32.3	14.0	12.8
		6	18.7	3.1	.0	7.0	87.2	16.5	12.9
		7	18.3	4.4	1.8	3.9	85.4	13.5	15.4
		8	10.2	4.7	2.7	1.1	87.5	19.7	13.4
		9	21.0	.0	5.0	3.8	87.0	14.5	25.3
		10	1.8	7.1	11.3	28.4	45.2	37.8	
		11		4.4	3.3			26.7	
		12		3.1	0.8	.0		17.1	13.1
		13		.0	0.9	.0		13.2	19.2
		14		3.7	1.0			13.2	
		15		15.6	3.3	3.6		14.9	14.7
		16		11.9	0.9	3.1		17.1	14.8
		17		3.0	1.9			15.7	
		18		3.6	.0	.0		16.2	12.7
		19		4.4	3.5	.0		15.3	17.3
		20		.0	.0	19.9		13.7	12.7
6	4	1	14.4	1.9	.0	1.0	73.2	12.8	16.7
		2	9.4	28.4	3.5		72.2	21.5	14.2
		3	12.4	8.1	9.8	31.1	59.0	28.9	14.3
		4	6.9	4.3	8.5	13.7	57.2	30.9	12.6
		5	11.1	6.4	3.8	19.0	45.7	24.6	13.9
		6	1.4	7.0	2.1	7.3	42.1	18.2	12.7
		7	13.5	22.5	2.1	4.9	74.6	15.5	14.1
		8	12.3	14.7	1.1	8.2	46.2	20.6	17.0
		9	7.9	6.3	1.1	20.9	41.7	13.2	13.7
		10	6.9	5.2	3.1	33.2	54.2	20.1	15.1

Southwestern Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
7	7	1	3.7	1.9		.0	40.9		13.6
		2	1.8	.0	.0	.0	12.5	14.1	14.0
		3	49.8	85.4	52.2	58.1	78.1	86.3	75.0
		4	55.0	43.4	58.5	17.8	78.7	81.1	86.7
		5	14.4	21.4	38.7	30.0	41.2	63.4	68.5
		6	6.4	3.5	1.7	62.9	44.4	24.1	80.4
		7	19.2	16.0	70.9	43.2	68.1	85.4	87.3
		8	1.1	1.1	1.4	.0	13.1	21.2	22.1
		9	12.6	2.8	12.3	20.8	56.1	67.8	57.7
		10	12.3	5.8	1.1	.0	26.0	18.9	13.3
		11		1.3	4.8	.0		13.3	12.8
		12		39.7	35.8	28.9		82.4	55.1
		13		9.0	22.3	13.5		77.1	59.6
		14		15.8	23.2	21.8		83.7	56.0
		15		74.6	20.4	52.6		86.7	60.9
		16		18.4	19.6	22.9		55.5	54.8
		17		41.2	54.0	53.9		87.0	57.4
		18		15.1	25.3	28.9		47.2	37.0
		19		68.1	116.3	13.4		86.6	81.5
		20		103.2	44.5	52.4		87.2	60.3
10	5	1	11.4				51.7		
		2	13.2				77.5		
		3	32.0				67.7		
		4	13.6				73.9		
		5	7.6				79.9		
		6	20.1				87.2		
		7	4.3				59.9		
		8	14.9				85.7		
		9	38.6				84.3		
		10	14.7				73.0		

Intermountain Region (R-4) Douglas-fir

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
Ogden Zone									
3	3	1	26.0	1.7	9.8	8.3	47.2	37.0	16.4
		2	24.7	4.4	33.4	16.0	16.7	27.6	65.8
		3	29.8	23.9	69.8	8.5	16.2	49.7	13.9
		4	33.1	19.3	27.6	6.0	30.6	49.8	22.1
		5	60.8	27.7	55.1	2.8	53.2	54.7	14.0
		6	28.6	17.2	16.8	22.9	31.5	48.2	40.1
		7	58.7	11.3	2.1	7.8	23.7	26.7	
		8	39.7	37.5	2.6	2.0	72.4	84.0	30.6
		9	18.8	25.7	102.8	8.8	32.3	55.5	18.1
		10	9.1	26.4	52.5	63.2	25.2	27.7	66.7
		11	45.2	2.1	65.8	38.5	39.1	69.3	26.1
		12	8.7	20.9	37.1	20.5	36.6	62.3	46.2
		13	9.1	1.3	26.2	4.0	17.3	23.0	14.5
		14	41.5	62.5	75.3	51.9	37.9	78.5	65.0
		15	55.5	52.6	47.4	51.2	35.7	38.9	37.5
		16	34.5	19.3	29.9	11.2	36.5	57.7	18.6
		17	44.7	11.0	54.9		21.1	20.2	
		18	75.6	58.7	38.9	19.0	60.7	84.2	22.7
		19	21.6	29.5	31.7	25.9	19.8	56.3	40.9
		20	22.9	31.6	74.0	14.9	49.2	38.2	14.2
		21	26.3	1.1	18.1	5.8	63.7	57.3	
		22	75.9	51.9		22.8	37.3		26.7
		23	41.0	16.4	68.7	27.0	20.0	31.4	86.0
		24	40.6	6.0	65.7	26.4	14.9	31.7	75.6
		25	34.1	10.1	55.2	31.7	20.3	20.9	25.6
		26	76.6	70.8	67.7	33.1	37.9	55.2	13.9
		27		18.2	40.8	13.2	29.8	33.6	19.7
		28	6.8	6.6		0.8	23.0	13.5	23.9
		29		20.7		2.4	67.4		20.8

Intermountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
3	3	30		.0	2.5	.0	13.7		14.2
		31		59.5		3.7	17.7		16.5
		32	14.7	7.0		7.7	21.7	22.0	17.7
		33		17.4	19.3	22.1	18.2	24.1	14.0
		34	0.8	5.8		4.1	13.7	19.2	23.6
		35		17.5	38.8	18.0	41.3	31.4	16.2
		36		38.0	63.3	20.0	40.8	58.7	14.2
		37		5.4	39.5	41.9	45.8	31.7	85.1
		38		37.0	55.7	33.2	24.3	62.0	78.4
		39		17.7			38.0		
		40		1.0			22.2		
13	4	1	.0	1.0	0.7	1.8	15.3	17.9	26.2
		2	.0	.0	.0	1.6	15.4	15.7	26.6
		3	.0	.0	.0		19.2	14.0	
		4	4.6	10.4	29.5	34.6	33.1	41.1	44.3
		5	.0	2.7	6.5	6.1	19.7	25.3	41.4
		6	0.9	3.2	9.9		28.1	21.2	17.2
		7	0.9	0.8	6.0	7.2	21.8	20.6	31.7
		8	6.9	17.5	24.5	19.6	57.0	51.2	42.8
		9	1.8	0.8	8.2	5.9	18.8	22.7	39.8
		10	.0	.0	.0	0.7	17.0	14.7	20.2
		11	2.9	.0	1.8	4.0	19.9	16.3	28.6
		12	.0	.0	2.3	0.9	13.1	16.7	15.3
		13	2.0	8.7	27.2	97.0	12.8	20.2	54.0
		14	.0	2.5	6.8	7.9	15.5	14.9	39.5
		15	0.7	.0	1.8	18.2	14.8	13.2	35.6
		16	.0	2.0	3.0	9.4	14.7	17.2	22.2
		17	0.9	0.8	6.1	11.8	16.9	15.7	57.7
		18	.0	4.3	1.9	12.8	18.2	22.1	37.1
		19	.0	1.2	24.9	4.5	17.4	19.6	18.9

Intermountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
15	1	1	8.7	23.7	16.0	22.5	46.0	60.7	57.9
		2	59.6	66.9	79.0	40.7	58.4	75.7	87.5
		3	0.7	.0	.0	.0	13.3	13.7	16.4
		4	10.7	2.2	16.5	5.9	19.4	24.2	53.0
		5	.0	.0	.0	1.3	14.7	13.9	13.7
		6	56.0	51.9	58.2	88.0	57.5	66.9	62.1
		7	35.2	14.5	22.1	29.5	37.2	51.3	58.4
		8	.0	1.7	1.0	.0	19.6	14.7	14.8
		9	.0	3.4	7.9	17.7	19.8	36.2	42.3
		10	2.1	0.9	5.3	12.1	22.7	16.5	61.3
		11	3.5	.0	4.6	12.7	20.7	16.4	32.7
		12	2.2	.0	6.4	3.6	20.2	22.9	34.7
		13	47.2	28.0	25.3	12.5	40.7	39.0	70.2
		14	81.6	41.3	58.4	32.2	36.4	46.0	55.0
		15	17.8	26.3	56.1	75.8	34.2	40.2	82.6
		16	90.3	43.7	63.5	41.9	54.0	72.1	87.5
		17	15.6	5.4	11.8	21.0	31.6	41.7	55.9
		18	.0	.0	.0	1.2	14.4	18.0	13.3
		19	3.2	29.1	23.9	63.6	32.7	55.3	68.6
		20	44.1	10.0	15.4	12.6	29.5	32.6	51.7
		21	2.8	1.5	4.6	19.4	22.0	24.2	62.2
		22	.0	.0	1.0	.0	13.9	14.8	14.2
		23	48.7	18.3	24.8	7.5	45.2	55.2	67.9
		24	2.8	2.7	9.1		27.4	48.2	
		25	40.6	25.7	16.9	29.1	67.2	83.8	73.7
		26	1.7	.0	1.8		13.4	15.2	
		27	88.0	29.0	65.6	61.1	28.6	68.5	75.2
15	2	1	.0	.0	.0	1.3	16.7	13.9	13.3
		2	.0	1.2	2.3	.0	17.4	15.1	15.8
		3	0.8	1.1	8.5		12.8	15.7	
		4	.0	1.7	7.2	22.3	12.6	18.1	62.8

Intermountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
15	2	5	1.6	0.7	3.5	.0	16.4	18.2	14.5
		6	22.2	10.4	21.7	28.0	25.4	24.7	25.8
		7	1.6	.0	3.7	1.3	12.8	15.8	15.2
		8	1.7	2.3	.0	.0	14.5	13.6	14.7
		9	7.7	1.1	6.2	2.1	12.8	13.7	16.7
		10	2.6	.0	1.9	1.9	16.1	13.3	21.3
		11	25.8	9.9	18.5	30.0	15.1	18.5	48.0
		12	6.4	5.3	5.8		22.6	14.9	
		13	.0	.0	4.3	0.9	13.6	12.5	14.6
		14	1.9	1.2	0.9	4.0	15.2	14.4	19.1
		15	.0	.0	0.9	.0	19.4	13.7	13.5
		16	64.5	17.1		17.8	42.6		30.3
		17	.0	2.5	1.0	3.9	17.0	15.8	27.2
		18	5.6	2.4	2.8	4.4	13.7	15.3	15.3
		19	1.2	3.9	1.8	1.3	16.7	13.5	13.1
		20	4.8	1.7	2.7	0.7	12.7	17.5	20.7
		21	7.0	1.3	19.0	5.4	21.1	20.2	35.8
		22	2.0	.0	1.1	0.8	13.2	15.2	13.6
		23	3.6	2.8	.0	.0	13.0	14.7	16.4
		24	.0	.0	.0	4.5	13.1	12.5	14.9
		25	0.8	1.7	2.0	1.6	15.8	13.4	13.6
Boise Zone									
12	20	1	15.2				87.5		
		3	18.8				87.5		
		5		.0					23.2
		8	2.6				64.1		
		10	2.6				19.5		
		11	17.8	3.3	6.2		48.1	30.9	21.3
		13	9.1				81.1		
		19	4.3						
		21	8.1				71.7		

Intermountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
12	30	5	3.0	.0	6.4	3.6		15.3	16.3
12	40	1			2.6	.0		13.2	20.7
		3	2.1	.0	1.9	5.5		13.1	15.2
		5	0.7	.0	1.4	3.2		13.6	27.8
		7				9.7			33.7
		9	15.0				83.2		
		10		.0					
		15	5.9				81.1		
		26		.0					
12	50	1		1.4	.0	.0			14.5
		2		.0	0.8	.0		13.4	16.7
		3		.0	2.7	0.7		13.4	18.0
		4		.0	3.4	0.8		12.7	21.0
		5		.0	.0	0.6		14.4	26.5
		6							
		7		3.7	.0			13.7	17.1
		8		3.4	.0	2.7		12.5	25.7
		9	6.9	3.8	8.0	2.7	65.6	29.7	34.6
		10		5.9	3.1	2.1		14.1	18.3
		11	8.2	6.8	1.7	1.3	43.3	18.4	40.2
		12							
		13							
		14		11.1	4.6	1.1		13.3	23.2
		15		4.0	5.1			15.7	
		16		6.3	3.7			18.2	
		17							
		18	5.1	5.4	5.8		71.7	12.8	
		19		5.1	1.5	.0		14.4	18.8
		20		0.6	8.0	1.9		47.7	65.4
		21	.0	3.8	1.1	.0	37.1	14.9	20.9

Intermountain Region cont'd

Forest	Unit	Cluster	Egg Mass '76	Egg Mass '77	Egg Mass '78	Egg Mass '79	Defoliation '77	Defoliation '78	Defoliation '79
		22		8.0	20.5	3.7		16.2	29.6
		23	10.1	3.8	1.7	.0	55.2	29.3	55.8
		24		11.1	4.2			35.7	
		25		3.6	1.2	0.7		21.9	17.8
13	80	1			21.9	14.5			42.0
		2			20.2	19.6			26.8
		3			6.8	7.2			40.5
		4			4.2	3.4			20.1
		5			9.5	3.9			53.7
		6			6.3	3.3			35.2
		7			20.5	6.9			37.7
		8			14.0	10.0			30.7
		9			34.0	17.4			50.2
		10			65.6	47.1			55.7
		11			43.0	38.8			28.2
		12			6.2	5.2			19.5
		13			27.0	11.6			26.3
		14			183.6	71.0			41.2
		15			39.3	8.8			56.3
		16			22.0	26.7			57.1
		17			61.8	37.3			32.0
		18			81.9	23.0			21.2
		19			15.8	19.8			40.9
		20			12.7	21.0			53.7

APPENDIX 4

Egg mass and defoliation means and standard errors (S.E.) by Forest, unit, and year.

Northern Region (R-1) Douglas-fir

Forest	Unit	Year	Egg Mass Densities			Defoliation		
			n	Mean	S.E.	n	Mean	S.E.
2	**	76-77	12	19.3	6.9	9	28.7	6.3
		77-78	9	22.8	13.0	--	--	--
		78-79	--	--	--	--	--	--
		79-80	--	--	--	--	--	--
3	**	76-77	10	28.9	7.5	8	40.6	6.5
		77-78	7	16.4	3.7	19	50.3	2.8
		78-79	19	23.1	2.9	19	33.5	2.8
		79-80	--	--	--	--	--	--
11	1	76-77	12	60.5	9.2	12	67.1	6.6
		77-78	12	35.8	7.4	16	63.1	4.9
		78-79	17	37.6	4.6	15	29.1	3.8
		79-80	--	--	--	--	--	--
	2	76-77	19	42.6	6.6	18	56.7	4.4
		77-78	18	31.9	5.6	18	58.4	3.2
		78-79	18	34.3	5.5	20	35.9	3.6
		79-80	--	--	--	--	--	--
	3	76-77	10	43.6	9.9	9	63.3	8.4
		77-78	9	27.7	6.9	18	44.8	3.5
		78-79	18	72.2	14.2	19	39.4	2.8
		79-80	--	--	--	--	--	--
	**	76-77	41	48.1	4.7	39	61.4	3.5
		77-78	39	32.1	3.8	52	55.1	2.2
		78-79	53	48.2	5.4	54	35.2	2.0
		79-80	--	--	--	--	--	--
12	**	76-77	11	20.3	5.1	11	44.3	5.9
		77-78	11	19.3	5.7	55	42.1	2.1
		78-79	55	37.7	4.0	50	34.0	1.7
		79-80	--	--	--	--	--	--

Rocky Mountain Region (R-2) Douglas-fir

Forest	Unit	Year	Egg Mass Densities			Defoliation		
			n	Mean	S.E.	n	Mean	S.E.
10	**	76-77	8	7.8	5.1	8	35.3	7.5
		77-78	23	11.4	2.0	51	59.5	3.4
		78-79	46	17.7	2.1	53	58.1	3.0
		79-80	53	25.8	3.2	--	--	--
12	**	76-77	12	20.2	5.9	14	53.8	5.3
		77-78	36	8.1	1.0	69	42.6	2.1
		78-79	66	14.1	2.0	82	41.7	1.8
		79-80	82	13.3	1.6	--	--	--

Southwestern Region (R-3) Douglas-fir

Forest	Unit	Year	Egg Mass Densities			Defoliation		
			n	Mean	S.E.	n	Mean	S.E.
2	13	76-77	--	--	--	--	--	--
		77-78	20	9.9	1.9	20	46.9	6.0
		78-79	20	17.9	3.1	19	66.2	5.7
		79-80	20	43.1	6.7	--	--	--
	16	76-77	10	38.1	5.1	10	81.5	2.5
		77-78	20	22.3	3.7	20	54.6	3.7
		78-79	20	36.3	5.3	20	65.6	3.4
		79-80	20	42.8	8.5	--	--	--
3	8	76-77	12	17.8	5.8	12	62.6	5.9
		77-78	20	15.1	2.1	16	36.0	3.1
		78-79	16	17.1	4.3	6	32.8	9.3
		79-80	11	37.1	10.6	--	--	--
	15	76-77	10	15.1	4.1	10	61.9	9.5
		77-78	20	4.4	0.9	20	17.5	1.4
		78-79	20	2.6	0.6	16	15.7	1.2
		79-80	17	7.8	2.9	--	--	--
6	4	76-77	10	9.6	1.2	10	56.6	4.1
		77-78	10	10.5	2.7	10	20.6	1.9
		78-79	10	3.5	1.0	10	14.4	0.5
		79-80	9	15.5	3.8	--	--	--
7	7	76-77	10	17.6	6.1	10	45.9	7.7
		77-78	20	28.4	7.0	19	61.5	6.6
		78-79	19	31.7	6.8	20	52.7	5.7
		79-80	20	26.1	4.8	--	--	--
10	5	76-77	10	17.0	3.4	10	74.1	3.7
		77-78	--	--	--	--	--	--
		78-79	--	--	--	--	--	--
		79-80	--	--	--	--	--	--

Intermountain Region (R-4) Douglas-fir

Forest	Unit	Year	Egg Mass Densities			Defoliation		
			n	Mean	S.E.	n	Mean	S.E.
Ogden Zone								
3	3	76-77	29	34.7	3.9	40	32.9	2.4
		77-78	40	22.3	3.0	34	43.6	3.3
		78-79	32	43.4	4.3	35	33.7	3.9
		79-80	37	18.8	2.6	--	--	--
13	4	76-77	19	1.1	0.4	19	20.5	2.3
		77-78	19	2.9	1.0	19	21.1	2.2
		78-79	19	8.5	2.3	18	33.3	2.9
		79-80	17	14.3	5.6	--	--	--
15	1	76-77	27	24.6	5.7	27	31.1	3.0
		77-78	27	15.8	3.6	27	39.6	4.2
		78-79	27	22.0	4.6	25	52.5	4.7
		79-80	25	24.5	5.0	--	--	--
15	2	76-77	25	6.5	2.7	25	16.9	1.3
		77-78	25	2.7	0.8	24	15.6	0.6
		78-79	24	4.8	1.3	23	21.6	2.6
		79-80	23	5.7	1.9	--	--	--
Boise Zone								
12	**	76-77	18	7.5	1.4	14	64.1	5.6
		77-78	28	3.3	0.6	25	18.7	1.8
		78-79	26	3.7	0.8	24	25.9	2.6
		79-80	21	1.9	0.5	--	--	--
13	80	76-77	--	--	--	--	--	--
		77-78	--	--	--	--	--	--
		78-79	20	34.8	9.2	20	38.5	2.9
		79-80	20	19.8	3.9	--	--	--